Mobile Location Center

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An Architecture for E9-1-1 in VoIP Networks

Engineering White Paper

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Amendment history

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1.0 Draft	*23 Feb 2004*	*Martin Dawson, Matt Broda, Mark Lewis*	first draft
1.1 Draft	*08 Mar 2004*	*Martin Dawson, Matt Broda, Mark Lewis*	Modified with review comments and extended with appendices
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Chapter 1 Introduction

1.1 Executive summary

This paper describes an architecture for the support of emergency calls initiated in IP based voice networks. It identifies a mechanism by which the existing emergency network interfaces can be used unchanged and defines the signaling mechanisms which allow the routing of emergency calls to be performed together with the delivery of caller location information without the need for static information to be retained in the emergency network.

Borrowing from the principles adopted to deploy cellular E9-1-1 Phase 2 functionality, this architecture similarly allows the necessary information to be extracted from the network and delivered dynamically within the life of the emergency call.

Issues associated with location determination in IP networks, the transition to future location technologies and differences between enterprise and carrier network VoIP are also discussed. Through this discussion it can be seen that a straightforward evolution of the access network exists that will support many deployment types.

1.2 Purpose and motivation

The deployment of VoIP networks is occurring at a steadily increasing rate. While this technology is currently (at time of writing) unregulated, the entry of mainstream carriers into the market and steady growth in end-user populations means that the support of emergency calling is becoming more imperative. Whether in response to regulation or simply to be able to provide an essential service to their subscribers, the operators of VoIP networks need a practical deployable network architecture to support emergency services calling. The purpose of this paper is to present, to the membership of the National Emergency Number Association (NENA), a proposal for an architecture that may be acceptable to all such that the whole industry can work toward a common goal for implementation and in as short a time frame as possible.

1.3 Terms and acronyms

ACD	Automatic Call Distribution (Call Center call distribution)
ALI	Automatic Location Identification (also ALI Database)
BTS	Base Station
CAMA	Centralized Automatic Message Accounting
CLID	Calling Line Identity
CRDB	Coordinate Routing Database

ECR	Emergency Call Report
ESP	Emergency Services Protocol
ESPOSREQ	Emergency Service Position Request
ESRD	Emergency Service Routing Digits
ESRK	Emergency Services Routing Key
GMLC	Gateway Mobile Location Center
GPS	Global Positioning System
HLR	Home Location Register
IAM	Initial Address Message
ISUP	ISDN User Part
LEC	Local Exchange Carrier
LGS	Location Gateway Server
Li	Interface reference point: LGS - LIS
LIS	Location Identification Server
Lv	Interface reference point: Call Server - LGS
MAC	Media Access Control (MAC address, a layer 2 address)
MIB	Management Interface Base
MSC	Mobile Switching Center
MPC	Mobile Positioning Center
PAM	PSAP to ALI Message specification
PCF	Position Calculation Function
PDE	Position Determining Entity
PLR	Perform Location Request
PSAP	Public Safety Answering Point
PSTN	Public Switched Telephone Network
RF	Radio Frequency
SMLC	Serving Mobile Location Center
SNMP	Simple Network Management Protocol
SR (S/R)	Selective Router - aka 911 tandem
TMG	Trunk Media Gateway
URI	Universal Resource Identifier
URL	Universal Resource Locator
ZDB	Zone Database function

1.4 References

[1] TR-45 J-STD-036 - "Enhanced Wireless 9-1-1 Phase 2", Telecommunications Industry Association, 2000

[2] NENA-05-xxx - "NENA Standard for the Implementation of the Wireless Emergency Service Protocol E2 Interface"

[3] "Real Time ALI Exchange Interface Agreement - Issue 6.1", AT&T and Pacific Bell, March 25, 1995

[4] Military Standard WGS84 Metric MIL-STD-2401 (11 January 1994): "Military Standard Department of Defence World Geodetic System (WGS)".

[5] NENA VoIP/Packet Committee presentations web site, http://www.nena9-1-1.org/9-1-1TechStandards/voip.htm

[6] "VoIP Migration Working Group Committee Subject: Routing of VoIP Emergency Calls to PSAPs" Submitted by: Patti McCalmont, Intrado, February 3, 2004

[7] OMA-LIF-MLP-V3.2.0-20031017-D - "Mobile Location Protocol Version 3.2.0 Draft", Open Mobile Alliance, 2003-10-17

[8] 3GPP TS 44.031: "Location Services (LCS); Mobile Station (MS) - Serving Mobile Location Centre (SMLC) Radio Resource LCS Protocol (RRLP)".

Chapter 2 E9-1-1 and Location

2.1 Voice to Emergency Network Interfaces

Before examining how VoIP subscribers can best be provided with support for E9-1-1 calling, it is useful to examine how existing voice networks interface to the emergency services network. The primary existing voice networks that do interface to emergency services are the PSTN as served by LECs and the various mobile networks operated by the cellular carriers.

The emergency services network, from this perspective, can be regarded as being made up of Selective Routers (SRs), Automatic Location Identification (ALI) databases, both local and national, and the Public Safety Answering Points (PSAPs) themselves with their various CAMA, and other, trunk connections and various data connections for querying the ALIs. Of course, beyond these network elements are the public safety organisations themselves (Police, Fire, Ambulance) and the communications networks that support them. However, for the purpose of this paper, these networks can be considered as contained and non-impacting on the interfaces under discussion.

A simplified view of this emergency services network is shown in Figure 1.

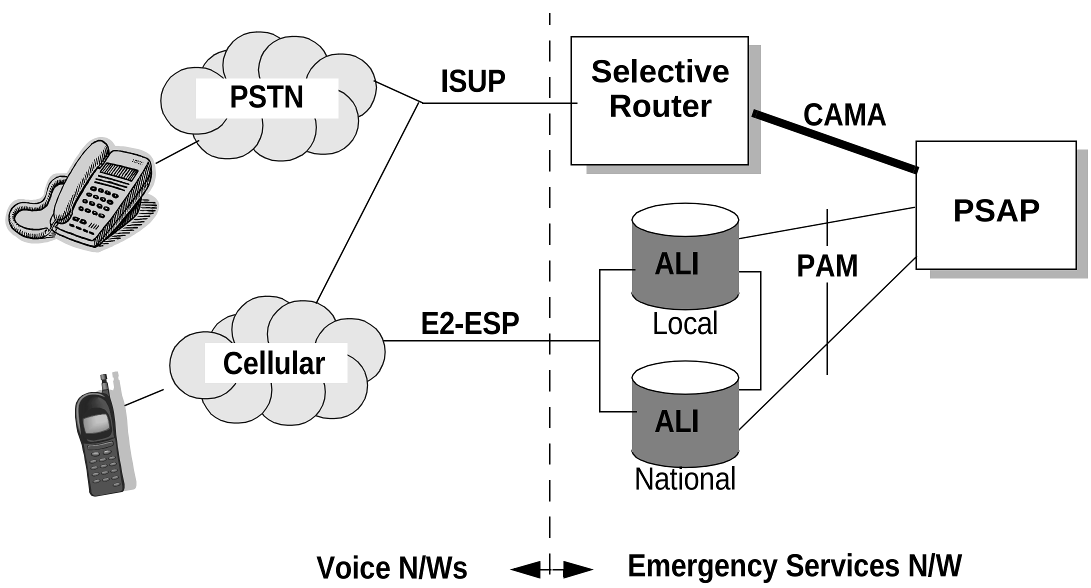


Figure 1 Emergency Services Network and Voice Network Interfaces

The goal of this paper is to outline an approach that will allow an additional Voice over IP network to be added to the voice network side with minimal to no impact on the interface to the emergency services network.

2.2 Key Location Functions in E9-1-1

The location of the subscriber, who is dialing emergency services, is used for two key purposes. The first is routing of the call, ultimately to the right PSAP, and the second is in the delivery of the location, for display, to the PSAP operator in order that emergency response units can be dispatched to the correct location. Referring back to Figure 1, these two functions are performed over the interfaces identified. Let's look at how these are performed for the main types of voice networks.

2.2.1 Location used for emergency call routing

In **wireline** voice networks, there is an association between the phone number of the subscriber (The Calling Line Identity - CLID) and that subscriber's location. This is generally, the home address of the subscriber as maintained by their local exchange carrier. In this case, the CLID becomes a ready-reference to location.

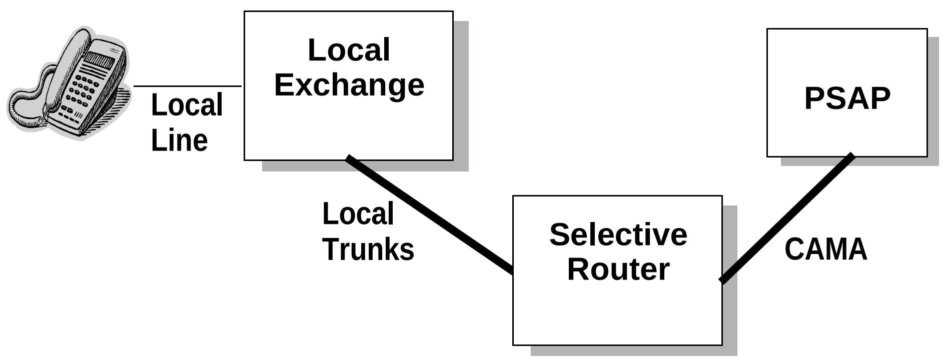


Figure 2 Wireline routing to local PSAP is implicit in the local line connection

Similarly, the incoming line to the local exchange switch and the switch itself provides an explicit indication of the appropriate routing of 911 calls. This permits the local exchange to work from a static configuration in terms of selecting the outgoing trunk on which to place the call so it goes to the correct selective router. The selective router, in turn, can use the same static association and CLID information to ensure that the call is routed to the correct serving PSAP for the subscriber's address. This relatively simple situation is shown in Figure 2.

In **cellular** systems, the association between the subscriber's location and their CLID is lost. Being - by definition - mobile, a cellular subscriber can be anywhere within the wireless network's area of coverage. Similarly, there is no physical wired line corresponding to the source of the call from which to associate a route to the correct destination. In cellular networks, however, there is a physical serving cell from which the call is initiated. The geographic granularity of these cell locations is generally sufficiently fine for the mobile switch to determine the correct trunk route to a corresponding selective router.

In many cases, this also provides sufficient accuracy for the selective router to determine which PSAP the caller should be connected with.

It is an internal procedure for the mobile switch to associate an outgoing trunk route with a serving cell. However, some signaling is required for the MSC to pass this same information along to the selective router so that it can determine the correct PSAP. The TR45 standard, J-STD-036 [1], defines mechanisms for doing this. The routing information is passed to the selective router in the ISUP call setup signaling in one or other newly defined parameters called the Emergency Services Routing Digits (ESRD) or the Emergency Services Routing Key (ESRK)[1]. The selective router examines the value of the ESRD/ESRK parameter in the call setup signaling and routes the call to the correct PSAP based on this value.

Note that there are circumstances where cell boundaries can span the boundaries of PSAP catchment areas. In this case, and ESRD or ESRK determined from a serving cell may not provide a reliable indication of a route to the correct PSAP[2]. Both ANSI-41 (generally TDMA, and CDMA) and 3GPP (generally GSM, EDGE, and UMTS) cellular networks have identified functionality to address this. In ANSI-41 networks a functional element known as a Coordinate Routing Database (CRDB) is defined. The network can consult the CRDB and, based on the geographic location of the caller (determined by different positioning technologies such as forward link trilateration, pilot strength measurements, time of arrival measurements, etc.), it will return an appropriate value of the routing parameter. As long as the geographic location is an improvement in accuracy over the cell location, this mitigates the problem of misrouted calls. Similarly 3GPP networks allow the switch to request a refined routing key value from the Gateway Mobile Location Center (GMLC) based on the geographic location of the caller.

This mechanism is illustrated in Figure 3 which shows a GSM network performing routing to a specific serving PSAP based on the determined latitude and longitude of the caller which is subsequently used to generate an ESRK that the selective router bases its PSAP selection on. Note the Zone

1. From a routing perspective the ESRD and ESRK provide the same information. The ESRK is assigned as a unique value associated with the specific call while the ESRD may be the same for any two or more calls being made from the same location but this difference is not pertinent to the question of routing. The use of the ESRK as a unique key is relevant to the location delivery function, discussed later.
2. The figure of 30% of calls misrouted because of cell/PSAP boundary spanning has been mentioned in various fora but the author is not aware of any definitive or authoritative study on this topic. The anecdotal consensus is that the proportion is significant and undesirably large.

Database (ZDB) function in the GMLC which performs the spatial analysis to determine which PSAP zone the callers location falls inside.

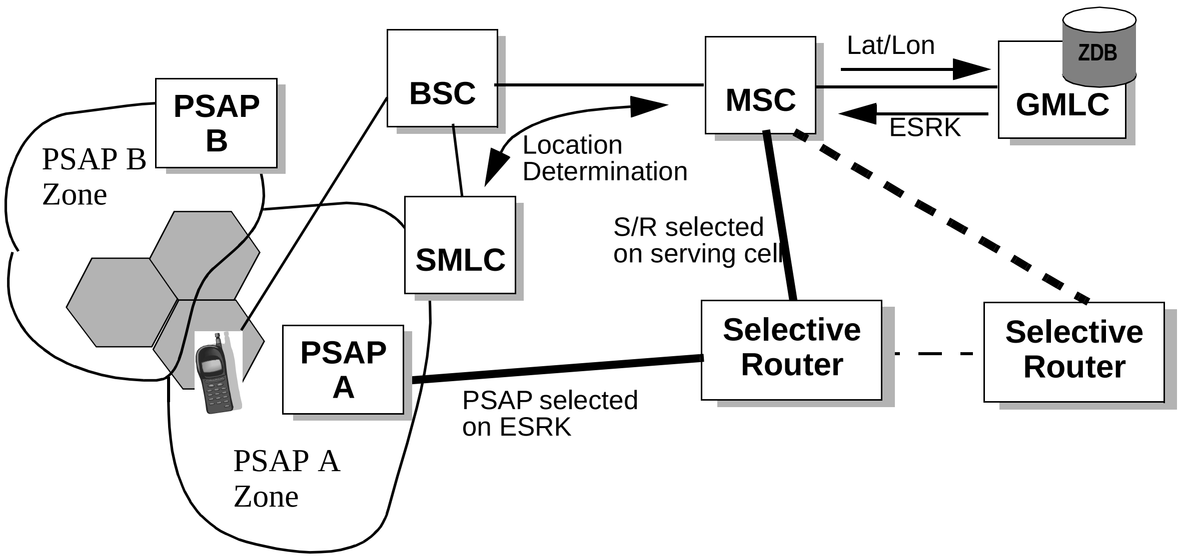


Figure 3 A GSM system showing the selection of a destination PSAP route based on the geodetic location of the caller. ESRK generated by GMLC from lat/lon used as a routing indicator

2.2.2 Delivering location to the PSAP operator for display

The second, independent, area in which location comes into play in E9-1-1 calling is the display of the caller's location to the PSAP operator. The need for this is that the PSAP operator can facilitate more rapid dispatch of the emergency service response units if the network can deliver the location rather than relying on getting this information from the caller - particularly where the caller may be unable to provide this information.

In a **wireline** voice network, necessary subscriber (or, at least, calling line) address information is stored in a database known as an Automatic Location Identification, or ALI, database. On receipt of an emergency call and, armed with the caller's CLID, the PSAP is able to query this database and receive, in return, the street address (also known as a civic address) information associated with the CLID. The physical interface over which the PSAP makes this query is variable. It may be an IP based interface over dial-up or broadband or it may be made over an X.25 packet interface. Similarly, the ALI may physically be co-located within the LEC and selective router, or it may be a remote national ALI handling the request directly or in tandem from the local ALI. Similarly, the protocol may vary but one known as PAM [3] is in common usage. These details are contained within the emergency network itself and not generally a concern of the larger voice network on the far side of the selective router.

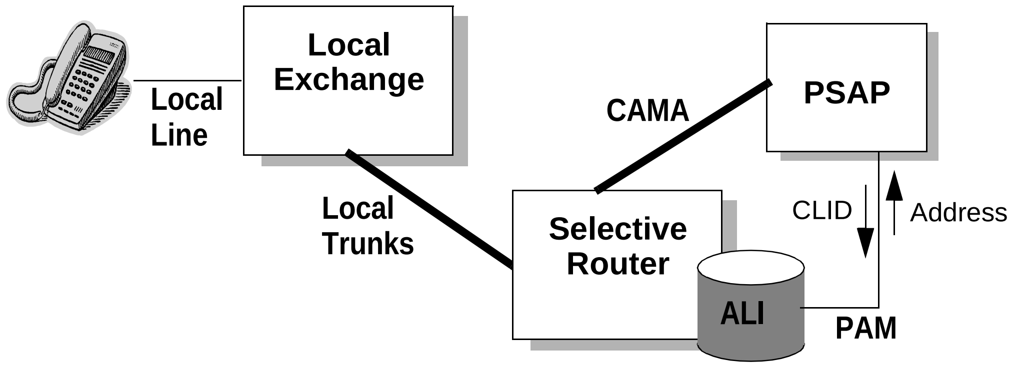


Figure 4 Wireline routing to local PSAP is implicit in the local line connection

In a **cellular** network, the same level of detachment with respect to this function is not possible. To begin with, the location of the caller is variable both initially and during the period of an emergency call. It is no longer possible to rely on a static database of location information that can provide an address against a CLID. It now becomes necessary for the PSAP to be able to request a dynamic location both for the initial position of the caller but also for any changes during the call. In addition, a civic address may no longer be pertinent to the location of the caller. By nature, cellular networks cover wide and varying types of territory. A conventional street address may no longer apply to a caller's location. Indeed, they may not even be in or by a street as the term is commonly understood. For this reason, a more universal reference system for location needs to be used. The solution generally adopted and, once more defined in J-STD-036 [1], is to use geospatial co-ordinates - or latitude and longitude - as defined in the WGS-84 coordinate system [4].

While J-STD-036 [1] does define a mechanism whereby this geospatial location can be delivered in the ISUP call setup signaling, it can be generally acknowledged that PSAPs do not support the necessary signaling interfaces nor customer premises equipment to receive and display this information. Also, there is no mechanism whereby an updated location can be delivered in the ISUP signaling. For these reasons, J-STD-036 identifies a new interface that the emergency network can use to query the cellular network. This interface is assigned the identifier of E2 and both J-STD-036 [1] and NENA [2] define a protocol which can be used over this interface called the emergency services protocol (ESP).

On receipt of an emergency call arising from a cellular network, the PSAP can initiate, via the serving ALI, a request on the cellular network to provide the geodetic location of the caller. This request is made over the E2 interface in a message called the ESPOSREQ (Emergency Service Position Request) with the response message identified as the esposreq - see Figure 5[1]. The location of the caller is determined by positioning capabilities native to the cellular network itself and different systems of network measurement, triangulation, or special handset capabilities such as GPS are used.

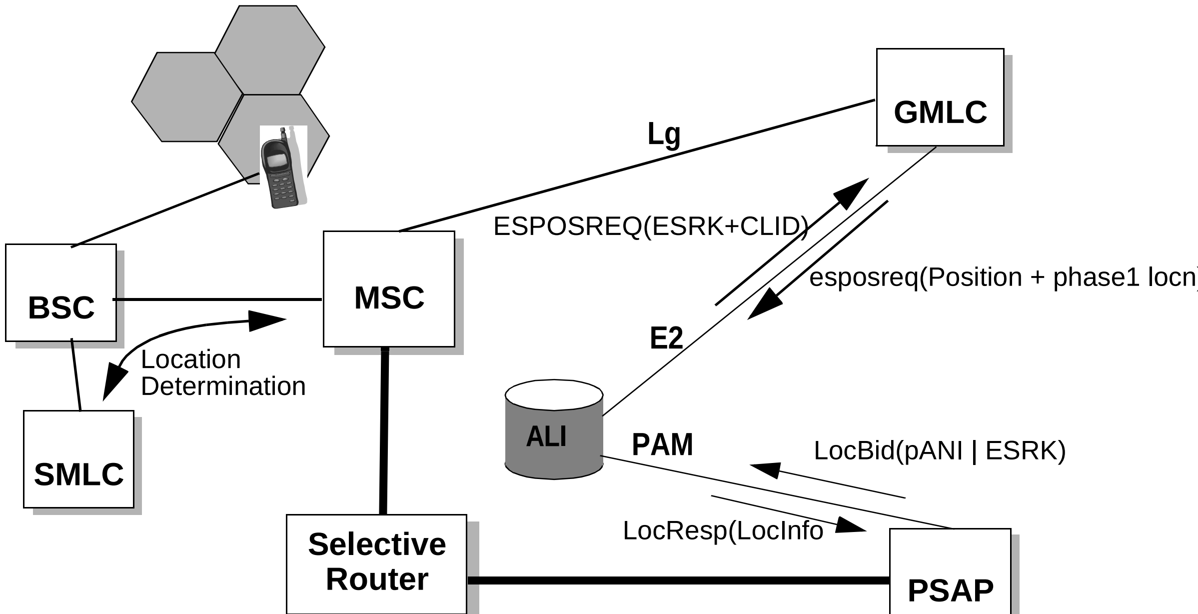


Figure 5 A GSM system showing the E2 interface being used to handle requests for dynamic subscriber location information in response to PSAP requests

2.2.3 Note on the support of "Phase 1" location in cellular networks

As described above, the network mechanisms and procedures defined in J-STD-036 [1] are around the provision of a geodetic (latitude and longitude) type location for the caller. This obviously implies a capability on the part of the PSAP to display location information of this type to the PSAP operator.

There is also consideration supported in the E2 interface messaging that allows the delivery of civic address type information. One application of this facility is in the support of PSAPs which are not equipped with the capability to receive and display geodetic type location information. This is part of what is often referred to as a Phase 1 E9-1-1 capability for cellular networks. Enhanced 911 calling was introduced in two phases into the cellular and

1. Compared to traditional wireline systems, cellular systems have some other challenges. For example, in terms of E9-1-1 all wireline callers are, almost by definition, local callers. As such, most PSAP systems are not equipped to deal with anything more than the 10 digits that may be necessary to identify a national number. A full international coding of a number - and remembering that an emergency caller can easily be roaming in from another country - of 11-15 digits cannot be delivered to a PSAP. In addition, an unregistered cellular phone without the need, even, to have a SIM card, can still be used to make emergency calls. In this case, there is no CLID for the phone.

To address this issue, the ESPOSREQ query can be made not just against the CLID of the caller but other keys can be used. Chief amongst these is the ESRK mentioned earlier which is assigned a unique value by the cellular network against a specific call in progress. The PSAP may not be delivered the real CLID of the caller, it may delivered a pseudo CLID (often called a pseudo-ANI or pANI). The emergency network may translate this into the ESRK to be used in the query. Moves are underway to ensure that the esposreq can be used to deliver the full international encoding of the caller’s number, where applicable, so that this may in future also be presented to the PSAP operator.

emergency services networks. Phase 2 defined the capabilities for delivering, generally more accurate, geodetic location information from the network. Phase 1 was generally targeted at providing location information to the accuracy of a serving base station location but, perhaps more importantly, that location information is delivered to the PSAP as a more conventional street, or civic, address associated with that base station. This can be noted in Figure 5 where the esposreq may contain "phase 1 locn" information. Depending on the nature of the PSAP, the ALI may provide the geodetic position and/or the phase1 civic address type information in response to the location bid.

This particular aspect is mentioned because the ability of the emergency network to receive civic address type information in addition to geodetic location over the E2 interface becomes important to the solution that may be put in place for IP based voice networks. This is discussed further in Section 3.3.3.

2.3 Voice over IP Networks and E9-1-1

Just as cellular networks have specific characteristics that result in new considerations for E9-1-1 compared to conventional wireline voice networks, so too do voice over IP (VoIP) based voice networks. VoIP network users have much in common with cellular network users in that there is no specific physical point of connection which dictates their identity. Just as a cellular phone can attach to the network anywhere that there is a point of coverage, so to can an IP based phone client attach to an IP network at many and varied points and take advantage of the voice service. From this perspective, it becomes necessary to view VoIP clients as essentially nomadic or even fully mobile to ensure that all usage scenarios are covered. For certain, many VoIP clients may be relatively static in terms of location (for example, a conventional form factor desktop phone with integrated VoIP client software will tend to be as stationary as any conventional wireline desktop phone) however, this situation is not explicitly predictable by the network, so an architecture that addresses mobility ensures that all usage scenarios are covered.

In terms of emergency call routing, the VoIP network introduces some additional challenges over wireline or cellular networks. In particular, the access network associated with a VoIP network can be highly distended. That is to say, in wireline the phone is tied to the specific local switch by the incoming line, in cellular the mobile switch has specific knowledge of the serving cell which has some degree of geographic association with that switch. But, in VoIP, the client may be attached to the network in another city, state, or, even, country than the one in which the serving call server is located - see Figure 6. There is not an immediate association to location that the call server can use to directly determine a route to a selective router let alone determine the correct PSAP.

Similarly, in terms of location delivery and display, a VoIP client may be appropriately identified by a street address, being on a relatively static access point, or it may be more appropriately identified against a geodetic location, as

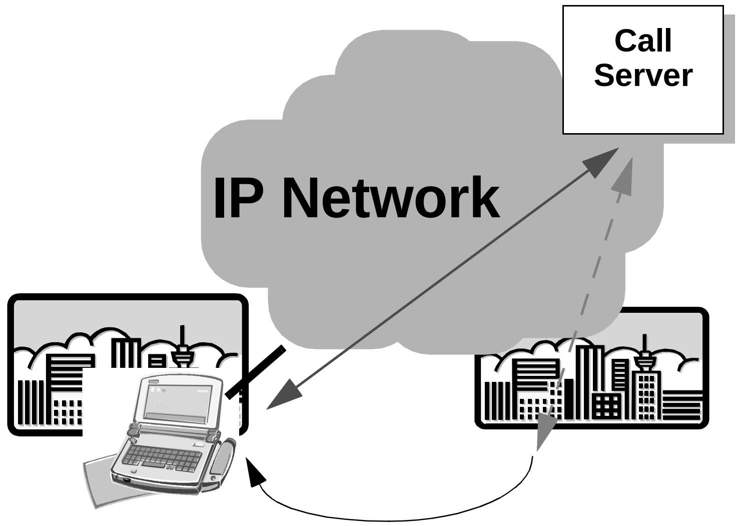


Figure 6 A VoIP client can move from one IP network access point to another without changing its signaling relationship with the voice service

in the case of a VoIP client connected by a wide area broadband wireless network.

The goal of this paper is to address each of these characteristics of VoIP by identifying the necessary supporting functionality in the VoIP network with minimal to no impact on the existing emergency services network interfaces.

Chapter 3 An E9-1-1 Architecture for VoIP

3.1 Revision

As described in the previous chapter:

- The boundary between the different major voice networks and the emergency networks can be identified at two key interfaces. These are the ISUP signaling and trunk link between the voice switch and the selective router and the E2 interface between the ALIs and the cellular networks.
- The two key functions of location in an E9-1-1 context are around the routing of the call to the correct serving PSAP, and the display of the location information to the PSAP operator.
- Wireline and cellular voice networks have specific mechanisms in place to address these key functions using the standard interfaces identified above.
- VoIP has much in common with cellular and introduces some differences of its own. It is desirable to define a VoIP network architecture that can interoperate over the existing emergency network interfaces with little or no modification to those interfaces.

This chapter defines an architecture to meet the goal stated in the final bullet point above.

3.2 Emergency Call Routing

For the sake of simplicity, the following discussion is based on the assumption that the Selective Router will use an ESRK provided in the ISUP call setup (IAM - Initial Address Message) to select the correct outgoing CAMA trunk for the corresponding serving PSAP[1].

3.2.1 Trunk - Media Gateway (TMG) to Selective Router routing

Opening up the VoIP network cloud, we can see that an emergency call needs to be delivered into the wireline voice network in order to enter the existing emergency services network. In VoIP networks, this is done by transiting the call out of the IP network and into wireline network via a Trunk - Media Gateway (TMG).

Since there are no dialed digits that can be used to effect routing of the emergency call (911 does not identify a unique destination), it is necessary for

1. As discussed in the sections on cellular emergency call routing, the actual key may be an ESRK or ESRD. Either may be used but this section defers the question of which to use in the interest of simplicity - it doesn't impact the manner in which routing is done.

the TMG selected to transit through has direct ISUP trunking capability to the selective router(s) that it supports routing to. To reuse the cellular mechanism for call routing, the TMG needs to pass on a unique ESRK to the selective router. That is, the TMG ISUP signaling needs to support the inclusion of this parameter in the IAM message. Note - where the TMG gets this ESRK value from is discussed in the next section.

Further, if the TMG has outgoing trunks to more than one selective router, it needs to be instructed as to which trunk to select based on the ESRK. That is, in the absence of routing based on dialed digits, the TMG needs to be told which outgoing voice trunk and ISUP signaling destination to select based on the value of the ESRK for that call. This implies a routing table that the network will use to ensure that the TMG is appropriately directed.

This TMG functionality is highlighted in Figure 7.

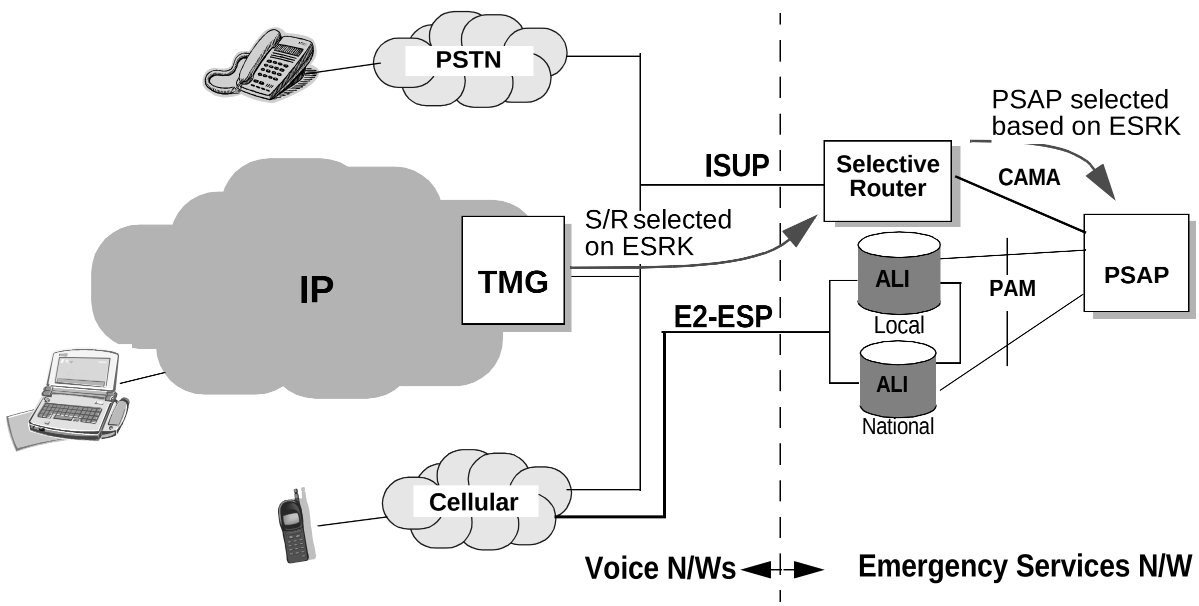


Figure 7 Given an ESRK, the Trunk - Media Gateway (TMG) selects the appropriate Selective Router trunks based on the ESRK value. The TMG populates the ISUP IAM with the ESRK parameter which the S/R then uses to select the applicable PSAP

3.2.2 Call Server to TMG routing

Looking further back into the VoIP network cloud, we see that the VoIP call itself is under the control of a call server. This network entity provides the equivalent functionality of a wireline switch or a cellular mobile switching center. The call server is responsible for setting up the initial state associated with an emergency call and routing it to the correct destination.

As has been noted at each step, the dialed digits do not provide a definitive route to the destination and, as noted in the previous section, the TMG outgoing trunk needs to be selected based on the ESRK so the appropriate selective router is trunked to. Since the call is delivered to the TMG by the call server, it is the responsibility of the call server to provide this ESRK in the IP based call setup and corresponding trunk selection through the TMG. Where the call server gets this ESRK value from is discussed later.

Since the call server has the responsibility to select a TMG based on the ESRK, the existence of a routing table within the call server is implied. This table will allow the call server to associate a TMG and trunk with a given ESRK value.

This aspect of call server functionality can also be seen in Figure 8.

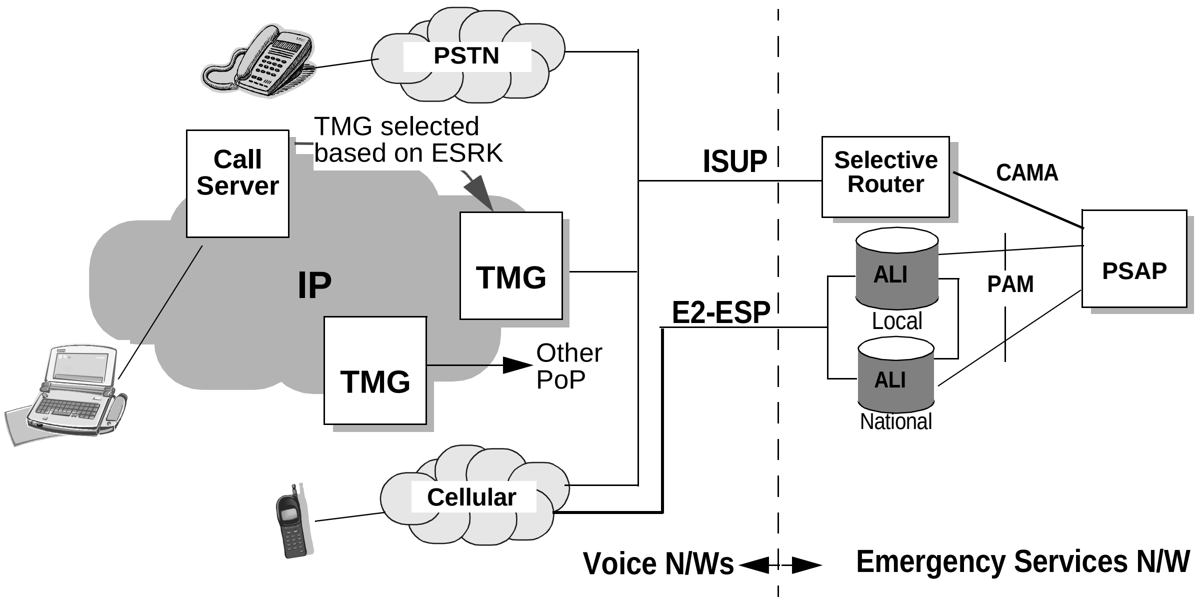


Figure 8 Given an ESRK, the Call Server selects the TMG located at the appropriate Point of Presence (PoP) to be able to perform trunking to the applicable S/R

3.2.3 Location Based Emergency Call Routing

This section will deal with the question of how the call server will determine the ESRK associated with final destination PSAP. This will be addressed by the introduction of a new network entity which interfaces to the call server called the Location Gateway Server (LGS). As a reference point, the interface between the call server and LGS is labeled Lv. This network entity will support two key functions:

- On request from a call server, and given the identity of an emergency caller/client, it will obtain the location of that client from the IP access network. For routing purposes, this location may be provided as a geodetic (latitude/longitude) location.
- Based on the location determined, and using a native spatial database capability which can identify an emergency services zone corresponding to a destination PSAP, it will generate a unique and applicable ESRK value that will indicate a route to the correct serving PSAP.

This function is illustrated in Figure 9. As shown, a single message and response is defined between the call server and the LGS which is used by the call server to request the ESRK. These are the EmergencyCallRequest (ECR) and the ECResponse messages. The key parameters of the request and response are the client ID in the former[1] and the ESRK in the latter.

A second message, ECTerminate, is also required to indicate the termination of the emergency call. As will be discussed later the LGS will maintain transient state information associated with emergency calls in progress. It needs to allocate an ESRK out of a pool of available numbers and it needs to be able to return the ESRK to this pool at the conclusion of the call. Thus, it is important for the call server to provide a message to the LGS indicating that the call is terminated. The ESRK associated with the call and provided in the call termination indication message will provide the necessary state association for the LGS. This function of the LGS is illustrated in Figure 9.

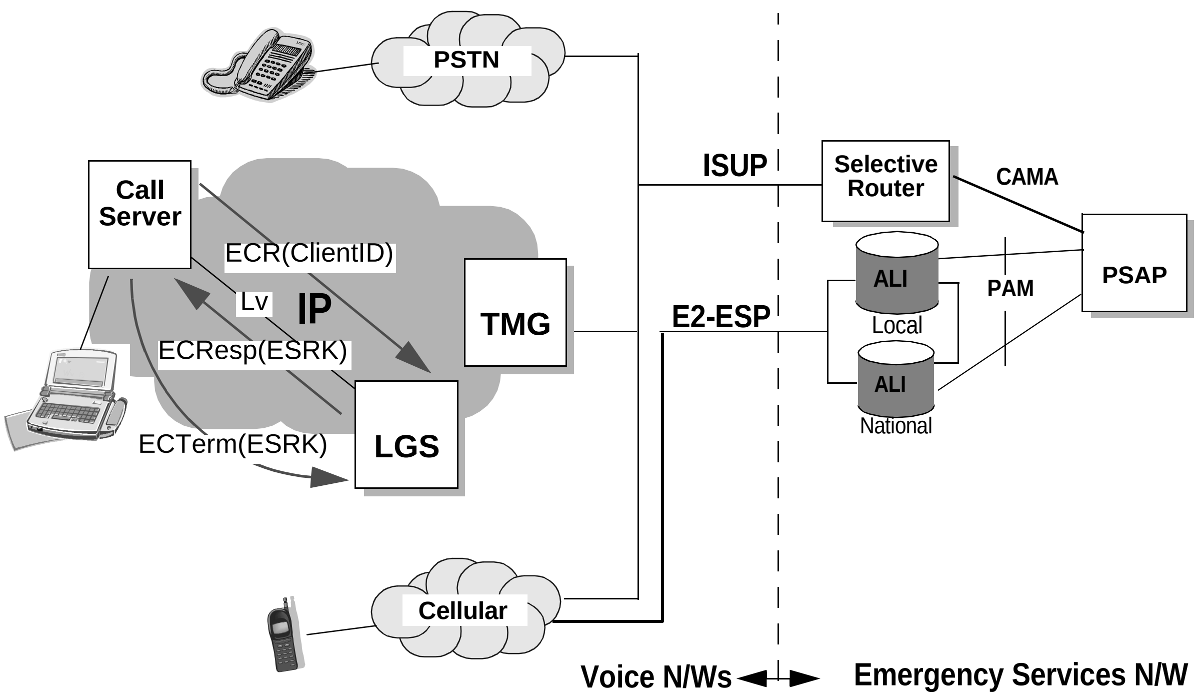


Figure 9 To determine an ESRK to route the call with, the Call Server sends an EmergencyCallRequest (ECR) to the Location Gateway Server (LGS). The LGS determines the client's location and generates a unique ESRK based on that location and returns it in an ECR response. When the emergency call completes, the Call Server informs the LGS with an ECTerminate message indicating which call by providing the ESRK. The LGS then flushes any state associated with that ESRK.

1. As discussed in a later chapter, an IP based voice network may use several mechanisms to identify a client. For many IP access networks, the MAC address of the client may be the only definitive identifier. In future, however, a range of identifiers may be possible, including IP addresses, URLs, RFC 2486 NAI, etc. The Call Server - LGS messaging should be defined to support a range of client ID types. In a practical deployment, it will be a case of ensuring that the access network, LGS, and call server use the same mechanism.

3.3 Emergency caller location delivery

The question of how an LGS can determine the location of a client device is deferred to a later chapter. Before looking into that question, the other aspect of location - the delivery of it to the PSAP operator - will be examined.

3.3.1 Reusing the E2 interface

As has been noted, the location of a VoIP client can be a transitory piece of information. As such, it is not adequate - as a general solution - to rely on a static data entry accessible by the emergency network and keyed against the CLID. As with cellular networks, the information associated with a subscriber should be determined, and is only valid, within the time that the call is active. Outside the period of duration of the emergency call, the emergency network stores no information and has no knowledge related to the identity or location of the subscriber.

In order to support Phase 2 E9-1-1 requirements, J-STD-036 defined the E2 interface between the ALI entities in the emergency services network and the location gateway entities (GMLCs and MPCs) in the connecting cellular networks. The emergency services protocol (ESP) supported over this interface was defined by both J-STD-036 [1] and in the NENA publication [2].

The recommendation of this paper is that this same E2 interface and ESP protocol specification be reused on the LGS to support the delivery of location information associated with VoIP emergency calls.

As shown in Figure 10, the ESRK becomes the definitive reference to the call in progress as well as being the routing indicator used in call setup. ESP allows the emergency network to make a request for a caller location which can then be delivered for display to the PSAP operator. The LGS already has the location information for the client since this was used to determine the call routing information. By caching the location in conjunction with the ESRK, call-in-progress state, the LGS is able to provide this location information in the esposreq sent in response to a request made over the E2 interface by the emergency network.

3.3.2 Mid-call location updates

Since cellular subscribers can, by definition, be mobile, the ESP semantics also support the ability for the emergency network to request an updated location for the caller. Using the same call identifier (e.g. the ESRK) as was used to request the location initially, the same ESPOSREQ message can be used to request an updated location. That is, there is a parameter in this message to indicate which type of location - initial or updated - that the emergency network would like. If an updated location is required, the cellular network knows that it should utilize its resources to see if a more up to date location is available.

This same mechanism will be available for the VoIP network. While in initial deployments, the IP access networks may only return relatively static locations (e.g. from switch port wire mappings), future deployments will be able to exploit advanced positioning technologies that can track a mobile IP device,

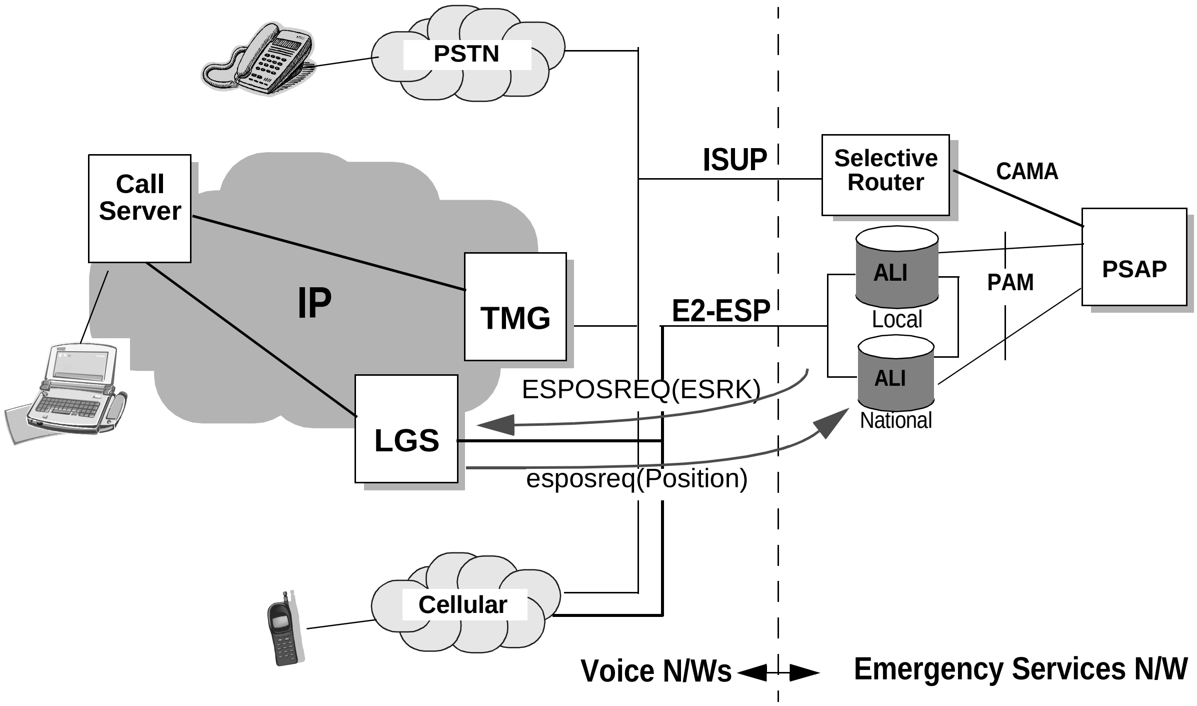


Figure 10 Since the ESRK has been delivered to the emergency network as part of the call routing process, it can now be used to query the LGS over the E2 interface. The LGS supports the existing E2 interface specification so the query is handled in the same way as a cellular location bid by the emergency network. Bids can be for initial location or for an updated location. The latter will prompt the LGS to query the network for an updated client location.

just as they can a mobile cellular device today. Since the semantics for requesting an updated location are already supported on the E2 interface, there will be no changes necessary to the emergency network in order for it to exploit this future tracking capability.

3.3.3 Civic Address and Geodetic Location Support

The introduction of Phase 2 E9-1-1 support for cellular emergency callers introduced the concept, and the precedent, that the location of the caller may actually be provided to the PSAP as a geodetic location. This has necessitated changes to PSAPs such that, to be Phase 2 capable, they need not only the ability to display a location in lat/lon format to an operator but also that these PSAPs have the necessary procedures and policies in place to relay location information in this form to emergency response teams. This includes being able deal with indicated accuracies that can vary below 50 meters at the 67th percentile and approach arbitrary levels of inaccuracy for the other 1/3 of calls.

This precedent can be taken advantage of for VoIP clients where, in the absence of a civic address which can be displayed to the PSAP operator, a geodetic location - just as is used for phase 2 cellular location - can be provided.

However, this does not mean that emergency calls from IP based voice networks need always be restricted to geodetic based location reporting. As was discussed in Section 2.2.3, the ESP signaling parameters as defined by NENA [2] includes a parameter called "location description". The NENA specification defines a number of different XML tag based fields that can be used to constitute this parameter. This opens the possibility that the LGS, in responding to an ESPOSREQ request over the E2 interface, can utilize this parameter to also provide a civic address for the caller.

As described in Section 2.2.3, in cellular systems this parameter has a nominal use around supporting phase 1 capable PSAPs where the location description provided will generally correspond to a street address identifier for the serving base station in the cellular network. However, this use does not preclude an alternative application in IP based voice networks.

Where VoIP clients have a relatively static location - for example, where the client is a conventional telephone form factor device with a relatively fixed desktop location - then the access network, which provides location to the LGS, may opt to provide a civic address encoding in addition to the geodetic location. A discussion on general location determination and the associated signaling is covered in the next chapter.

A valid question is how the emergency services network can know that it is receiving a civic address for the caller rather than a nominal base station address. This can be discriminated in a number of ways. The key is that the emergency network can be aware that it is interfacing to an IP based voice network rather than a cellular network. Three potential ways to perform this discrimination are:

- The emergency network will generally select the E2 interface that it needs to send a request to on the basis of the ESRK associated with the call. ESRKs tend to be allocated to network operators in pools. This same association can allow the emergency network to infer the nature of the connecting network.
- The esposreq response contains a parameter which is the Company ID. This could be used by the emergency network to distinguish IP vs. cellular carriers.
- The position data parameter in the esposreq which contains the geodetic location also contains a sub-parameter called "position source" which indicates the technology used to establish the location. New code points will need to be allocated for IP network positioning technologies. This could be used by the emergency network to establish that the location is being provided by an IP voice network.

The mechanisms discussed above identify how the existing cellular E9-1-1 phase 2 infrastructure and interfaces in the emergency network can be effectively reused with little or no modification to support the delivery of caller location from IP based voice networks.

In order to minimize the need to transform and translate the information related to location, it is recommended that the specifications used for this on the E2 interface are reused within the signaling of the IP network. That is the geodetic location coding defined in [2] as well as the XML tag encodings also defined in [2] by NENA are also recommended for use between the IP network elements as they are delivered through to the LGS.

Chapter 4 End to End - Adding Location Determination

There are numerous approaches to location determination within IP networks. This paper does not attempt to be prescriptive in addressing this issue. A number of things will affect the type of solution put in place. Amongst these are:

- The nature of the connection used by the client. That is, whether it is a domestic broadband connection, an enterprise IP switch connected client, a wireless client connecting via a campus wireless LAN, etc.
- Legacy circumstances. That is, the extent to which the clients, access devices, and switches have native support for location delivery versus the need to overlay a solution for location determination on existing infrastructure.
- The type of location information and accuracy required for a given target environment. For example, are static civic addresses with sufficient geodetic accuracy for routing sufficient or is a more accurate geodetic location required in the absence of a civic address?

The NENA website itself has a number of submissions and proposals around different positioning technologies for IP [5] and any one of these may be adopted in a given access network.

4.1 The Location Identification Server - LIS

This paper proposes that an intermediate network entity be defined which provides a uniform query interface to the LGS network element such that it need not be concerned with the nature of the positioning technology used. This arrangement is shown in Figure 11.

The newly identified network element is the Location Identification Server (LIS). This network element sits between the LGS and the access network and invokes the applicable positioning technologies. It supports a simple request/response message that allows the LGS to obtain the location of a client.

4.2 Client Identifier Options

In order to do this, the LGS needs to provide a client identifier which is meaningful to the LIS and significant within the access network that the client is attached through. Types of potential client identifier vary but some candidates are:

- Ethernet MAC address
- MSISDN - international encoding of corresponding dialable digits

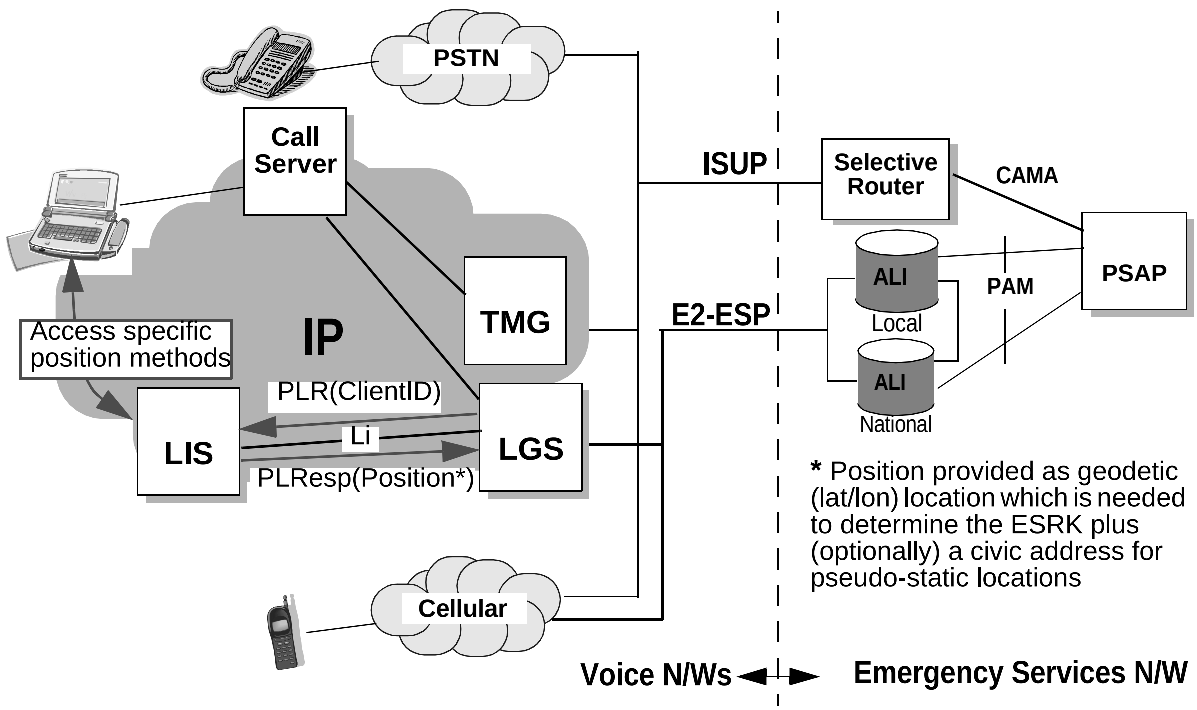


Figure 11 The Location Identification Server (LIS) provides location capabilities specific to the IP network access point that the client is currently occupying. It invokes access specific positioning methods in response to a PerformLocationRequest (PLR) sent from the LGS for a particular clientID.

- RFC 2486 Network Address Indicator - user@realm style address
- SIP URI
- Some other network element, e.g. LIS, generated handle to the client that is independent of other addressing schemes.

The above list is by no means definitive but the definition of the query messaging between the LIS and the LGS needs to be defined such that these and other forms of client identification can be supported over this interface. An important driver of the form of client identification supported is which identifier can be provided by the call server function in its request to the LGS. Any practical network deployment will need to ensure that the same client identifier form can be used meaningfully by the call server, LGS, and LIS.

By way of example, in initial implementations of this architecture where the access network and client devices are largely legacy, and without native location determination capabilities, the likely candidate for many deployments may be the MAC address.

An example of an end to end solution using a LIS that employs SNMP bridge MIB polling and MAC address association is shown in Appendix A.

4.3 Geodetic vs. Civic Address Location - revisited

As discussed in Section 3.3.3, location may be provided as a geodetic location for the purposes of call routing plus, optionally, a civic address that can be displayed to the PSAP operator. The parameter in the response message from the LIS to the LGS that specifies the returned location should support a coding that supports both of the location formats concurrently. The geodetic location must always be provided in order to support emergency call routing. Also as discussed in Section 3.3.3, it is recommended that the specifications used for coding location are the same as those on the E2 interface. That is, if the geodetic location coding and the XML tag encodings defined in [2] by NENA are used to encode the location provided to the LGS by the LIS, this will eliminate the need to translate and transform the information as it is passed from the LGS to the emergency services network.

Chapter 5 The future - filling the gaps

In the short term, the solutions provided to support emergency services for IP based voice networks may be sub-optimal. This is to say that, in the absence of native support for location determination and delivery in the IP access network, a number of work-arounds and operating constraints may need to be adopted. See Appendix A for an example implementation on a legacy access network. However, this qualification is very much restricted to the details of the access network and the manner in which location is determined.

The architecture that has been outlined in this paper - from the LIS through the LGS, call server, and TMG network entities interfacing to the emergency services network ISUP and E2 interfaces - should meet the needs of emergency calling from VoIP networks well into the future. Further, as more standardization occurs at the IP access and native positioning support is deployed, this transition to more reliable and accurate location determination will be able to occur seamlessly without impacting the VoIP to emergency network interface. The changes will be perceived as an improvement in coverage and quality of service for VoIP emergency callers as well as ease of deployment for VoIP operators but without impacting the operation of the emergency network generally.

In addition to the above, as the emergency network infrastructure evolves away from the current legacy of CAMA trunks and PAM interfaces, individual PSAPs will be able to interface directly to the IP network. The same functions of call routing and location delivery will still be needed and the mechanisms described can still be utilized. Instead of routing out to ISUP trunks, the call server can direct the call to a direct VoIP based ACD function. The ESP messaging defined in [2] is already IP based and the option becomes available for updated PSAPs to query the LGS directly instead of their requests being proxied through an ALI.

5.1 Using DHCP to improve client integration

One of the compromises that will need to be made in the short term with legacy IP clients and access networks is that neither has any knowledge of location determination and its associated signaling. As such they cannot actively contribute to the optimal performance of location determination (see Appendix A for an example of such a legacy network).

Referring to the architecture defined in the previous chapters, a lack of native location capability in the access and client does result in some of the following constraints:

- There is no explicit way for a LIS be aware of which IP clients are VoIP and which are subject to being located. Since IP clients may move freely from one point of access to another in an IP network, it can place a requirement on a LIS to constantly poll all potential access points to determine the location of a given client.

- Without an ability for a client to auto-discover the LIS which should be serving its location, there is no ability for that LIS to inform the call server and subsequently the LGS as to which LIS should be interrogated for location. This can place a requirement on the LGS to attempt to determine the correct LIS based, for example, on client IP addresses or to query multiple LIS concurrently - which is an inefficiency.
- Without a native positioning capability in clients, the ability of the network to support sophisticated positioning technologies such as GPS or network measurement techniques is severely limited.

Since the identity, location, and capabilities of the LIS will vary from access network to access network, it is recommended that in the future DHCP be used to advise IP clients of the identity of the serving LIS. This will permit two major optimizations:

- The client will be able to explicitly register with the LIS so that it is known to that entity for purposes of location. This will also establish a signaling relationship that can be used for advanced positioning mechanisms if supported. It also offers the opportunity for the LIS to assign a client-specific identifier which the client can provide to network services such that no other client key is required for the purposes of location requests through the LGS/LIS network.
- The call setup signaling to the call server can be modified to support the ability of the client to forward the serving LIS identity to the call server. This in turn can be communicated as part of the location request to the LGS, permitting the LGS to have explicit knowledge of the appropriate LIS to query.

These optimizations are illustrated in Figure 12.

5.1.1 A note on supporting international emergency calling

It is an interesting characteristic of VoIP networks that the distance between a client user and the call server handling the call processing may be arbitrarily large. A VoIP client can typically use the same call server regardless of the point of attachment to the network. So, the client may be in a different city, a different state, or even a different country.

It has been an implicit assumption in the discussion to date, that the call server has in built knowledge of the LGS that it should inform of the incidence of an emergency call and request routing information from. While this may hold true of a nationwide carrier with points of presence across many states, it may prove difficult for some VoIP network operators to provide the same ubiquity of presence. When the question of supporting international calling is raised, then it becomes even less likely that this assumption will apply.

This constraint will likely continue for the short term. However, the use of DHCP may, in the future, also provide a mechanism for dealing with this. In

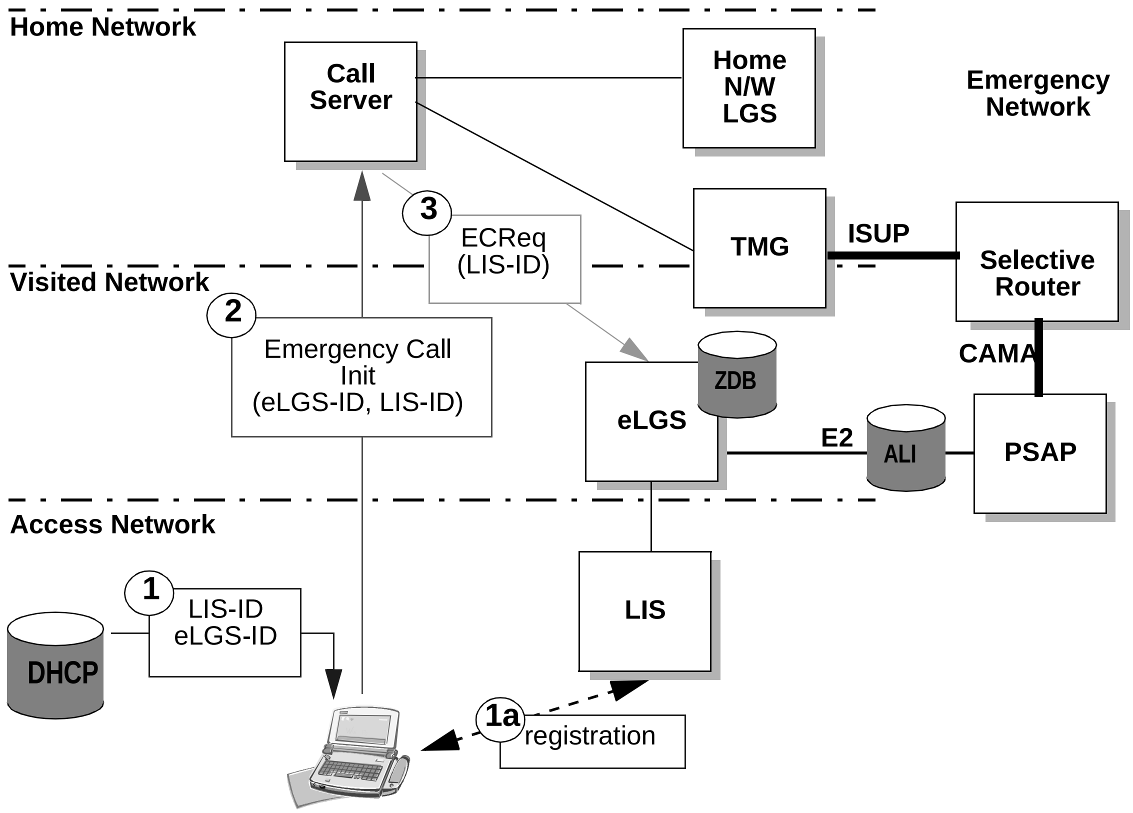


Figure 12 Shows a client registering with a DHCP server delivering LIS and eLGS information plus these parameters being tandemed to the call server and eLGS

1. DHCP server provides LIS and eLGS identities on initialisation
1a. (Optional) Client registers with LIS to establish signaling relationship for future positioning
2. Client provides eLGS and LIS identities to call server on emergency call initiation
3. Call server provides LIS identity to eLGS in emergency call request

this instance, the registration of a client on a local network can involve not only an indication of the serving LIS identity but also an indication of the applicable emergency LGS (eLGS).

With this facility, the client can provide the eLGS identity to the call server. This introduces the possibility of a network of regional LGS platforms to serve the VoIP network. The ESRK allocation pools can be efficiently distributed between these LGS and they can retain the responsibility of maintaining the spatial boundary information for the emergency service (PSAP) zones in their regions.

The signaling associated with this scenario is also shown in Figure 12. Note that the call server was able to refer to an eLGS in the visited network rather than the one in the subscriber's home network. This allowed the appropriate ESRK for the PSAP in the visited network operator's region to be allocated by that operator. Further, the PSAP in that region only needs to have an E2 interface association with that network's LGS and not the home network LGS.

Chapter 6 Enterprise versus Carrier VoIP network deployment

It has been a fundamental assumption in the architecture described in this paper, that the VoIP network operator has sufficient points of presence in each of the regions of interest to be able to route the emergency calls onto the local network and into the emergency services network. This may be true of a public carrier network which operates its own TMG platforms that tandem directly into the public wireline network but it is not true of an enterprise operating a VoIP network over its intranet.

In the case of an enterprise VoIP operator, this may not be an issue where the PABX or other PSTN gateway utilized by that enterprise is collocated with its user population. However, if the user population is widely geographically distributed via a wide area intranet and/or VPN links and they share a common PSTN gateway, then there is no native mechanism to support routing to the correct PSAP.

- For a collocated user population, the class 5 switch in the local operator network which provides the enterprise service, looks after the subsequent routing of the 911 call to the correct selective router and PSAP.
- This local exchange interface does not support the use of an ESRK in the call setup signaling to indicate a preferred route and a local exchange will not tend to support the necessary trunking to remote selective routers for out-of-region callers.
- For small and medium enterprises, it would not necessarily be economical to operate an LGS nor would it be optimal to distribute ESRK pools around arbitrary numbers of enterprises.

Despite these constraints, it is still desirable to utilize the architecture that has been described as the challenge of routing calls from geographically distributed callers needs to be addressed. While there are alternative proposals [6] these tend to rely on direct dialing local access numbers for PSAPs. While this is effective in the short term, it is by definition bypassing the existing mechanisms and processes for emergency call distribution.

At least two possible approaches to supporting the enterprise environment in the long term exist.

- Through the standards process, the local operator switch interface could be modified such that the ESRK can be delivered in the call setup.

This approach has a number of limitations including the fact that the time lag in defining this signaling and having switch vendors implement and deploy it can be very large. More significantly, it doesn’t address the concern that the local operator and switch is unlikely to maintain direct trunks to all required destination selective routers.

- Enterprises can seek emergency service support from public network carriers that support VoIP deployments. This means utilizing the LGS and TMG resources of the public carrier but only for the purposes of emergency call routing.

In this situation, the enterprise would still provide the LIS functionality within their intranet IP access. Using the equivalent of the DHCP mechanism described in Section 5.1.1, the enterprise client can be advised of the carrier LGS applicable to emergency calls in that location and relay this to the call server at call setup. At the same time the identity of the serving LIS can also be relayed via the call server to the LGS.

This arrangement is illustrated in Figure 13. The ability to support a solution in this configuration depends on the acceptance of the conventions around emergency services provision by public VoIP carriers. In turn, the solution will not become ubiquitous until VoIP carriers with points of presence in all potential calling areas exist.

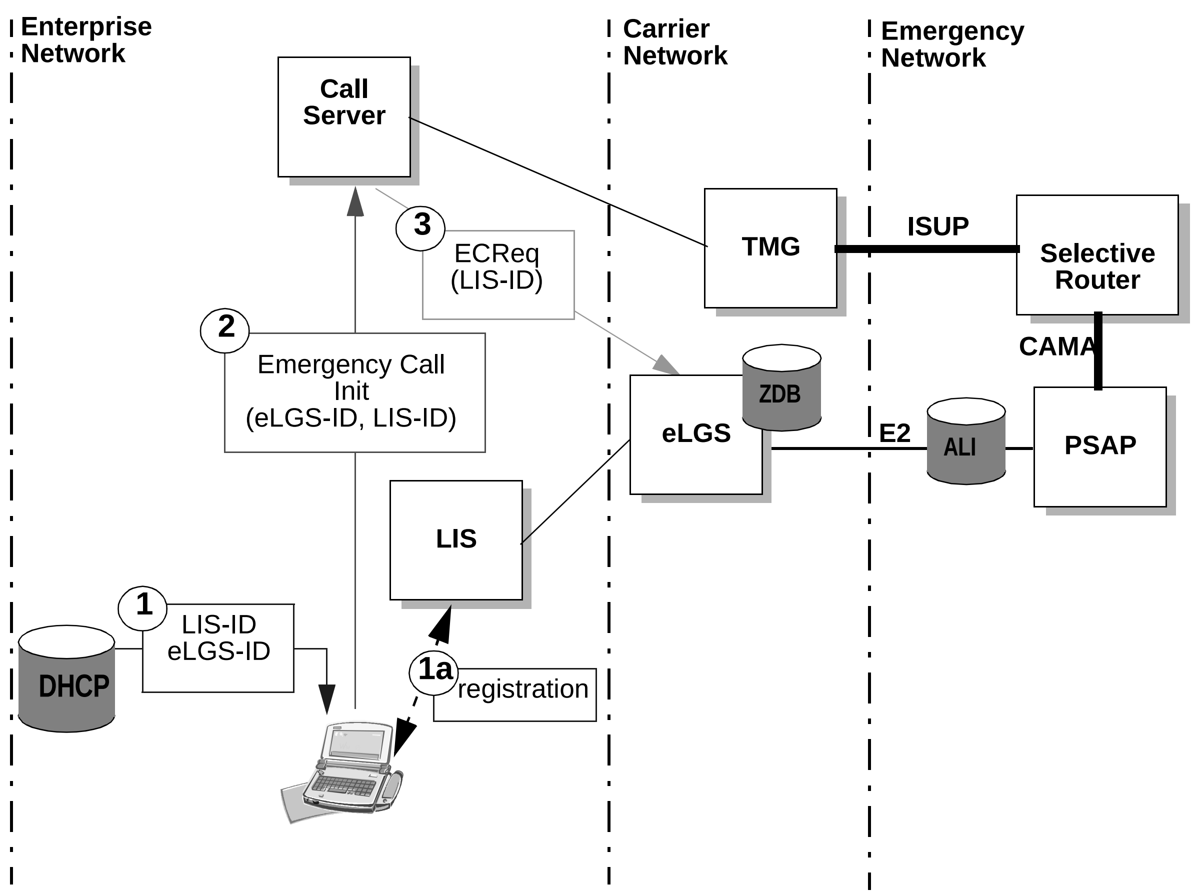


Figure 13 Shows the enterprise client and call server using the carrier LGS and TMG to route emergency calls into the emergency network. The location queries from the emergency and carrier network utilize the enterprise-bound LIS to determine the location.

Chapter 7 Next Steps

Defining an architecture which identifies the network elements and associated interfaces and the signaling relationships between them is the equivalent of a Stage 2 specification in standards language. This still leaves the, not inconsiderable, Stage 3 definitions to be done in which the details of the signaling protocols themselves are specified including all of the messages, parameters, and error scenarios.

Also, given an architecture that leaves the emergency network interfaces largely untouched, there is still the need to define a practical solution around legacy IP access hardware and client software.

These two areas point out the work which needs to be done in the short term.

7.1 Short term initiatives required

7.1.1 Protocol definitions

In the area of protocols, there are two significant interfaces which need to have the protocol definitions specified.

- The Lv interface protocol to be utilized between the Call Server and LGS need to be defined. The key messages are the Emergency Call Request, Response, and Terminate. Certain critical parameters have been identified for these messages in the body of this paper. The details of the transport and session protocols (e.g. SIP on TCP/IP) are yet to proposed.
- The Li interface protocol to be used between the LGS and LIS network entities is similarly yet to be defined. A possible contender on which to base this definition on is the Mobile Location Protocol defined by the Open Mobile Alliance [7]. This protocol is specifically designed for performing location queries, has an XML specification and utilizes [S]HTTP. The latter would be a particularly effective transport where the Li interface needs to span, for example, a carrier and an enterprise network.

It is quite urgent that the specific protocol families to be used on these interfaces be identified as quickly as possible so that ad hoc working groups can be established in the appropriate standards fora or, at least, a liaison be sent to those fora proposing that the first draft be developed within some other forum for subsequent submission.

The third area of protocol work that needs to be addressed in the short term are the changes and conventions around the use of ESP over the E2 interface. Changes to this protocol are extremely minor:

- Definition of one or more new code points for the Location Source parameter that will identify positioning technology as used in IP access networks rather than just cellular networks.

- Introduction of a convention based on a particular criterion (see Section 3.3.3) by which the PSAP can determine the nature of the civic address. That is, a convention by which the PSAP can discriminate a subscriber address vs. a Phase 1 E9-1-1 nominal BTS address.

These particular aspects of the ESP definition can be addressed through the existing working groups within NENA.

7.1.2 Location technology for legacy access development

In the short term the architecture defined in this paper will be applied to existing VoIP networks which consist, at the access, of legacy VoIP clients and access switching components that do not have any native location capability. This creates a challenge for the LIS in that some proprietary mechanisms will need to be developed in order to extract location information from these legacy networks. However, since the Li interface protocol will effectively abstract this aspect away from the rest of the network, these proprietary solutions will be able to be independently pursued on a case by case basis. That is, different vendors, network operators, and third parties will be able to develop these solutions competitively and in relative isolation without any implication of an end to end proprietary implementation being needed.

7.2 Longer term initiatives

A significant driver for new protocol definitions in the near future will be around the definition of standards to support native positioning in the access network. This will add very powerful mechanisms for dynamic discovery and high accuracy location determination. It will be very important to define protocols in the appropriate fora so that different client software and hardware vendors and access equipment vendors will be able to deliver solutions that can effectively interoperate. Areas of standards development are:

- Definitions of the access discovery mechanisms such as DHCP described in this document or other.
- Client to LIS protocols for advance positioning technology support. An analogous example is the RRLP protocol in the 3GPP standards suite [8] which defines a set of messages that can be used to exchange information between a mobile device and the network for the purposes of location determination - e.g. exchanging GPS assistance data and measurements for determining GPS based location determination.
- Enhanced client to call server communications for the purpose of delivering the serving LIS-ID, eLGS-ID, and even location information. This will need to be added to the various client VoIP protocols in turn since there are already a number contending for general use.

Ultimately, also, the LGS and LIS platforms should serve as a generic location delivery platform for location based services working to IP based clients - whether the clients are for voice services or other data applications. This will require additional interface semantics to the LGS on an additional services interface distinct from E2. An obvious candidate for a protocol to support this, is the previously mentioned MLP [7].

Apart from protocol definitions, there will be a fertile field for further development and commercialisation of positioning technologies for IP based access networks and clients. GPS has already been mentioned but other technologies such as network triangulation and RF mapping within wireless LANs are also possibilities.

Appendix A An example network deployment

Figure A.1 shows a simplified example of a VoIP deployment where the network operator is a carrier and the subscriber population are within enterprise managed networks. That is, this shows virtual private voice network

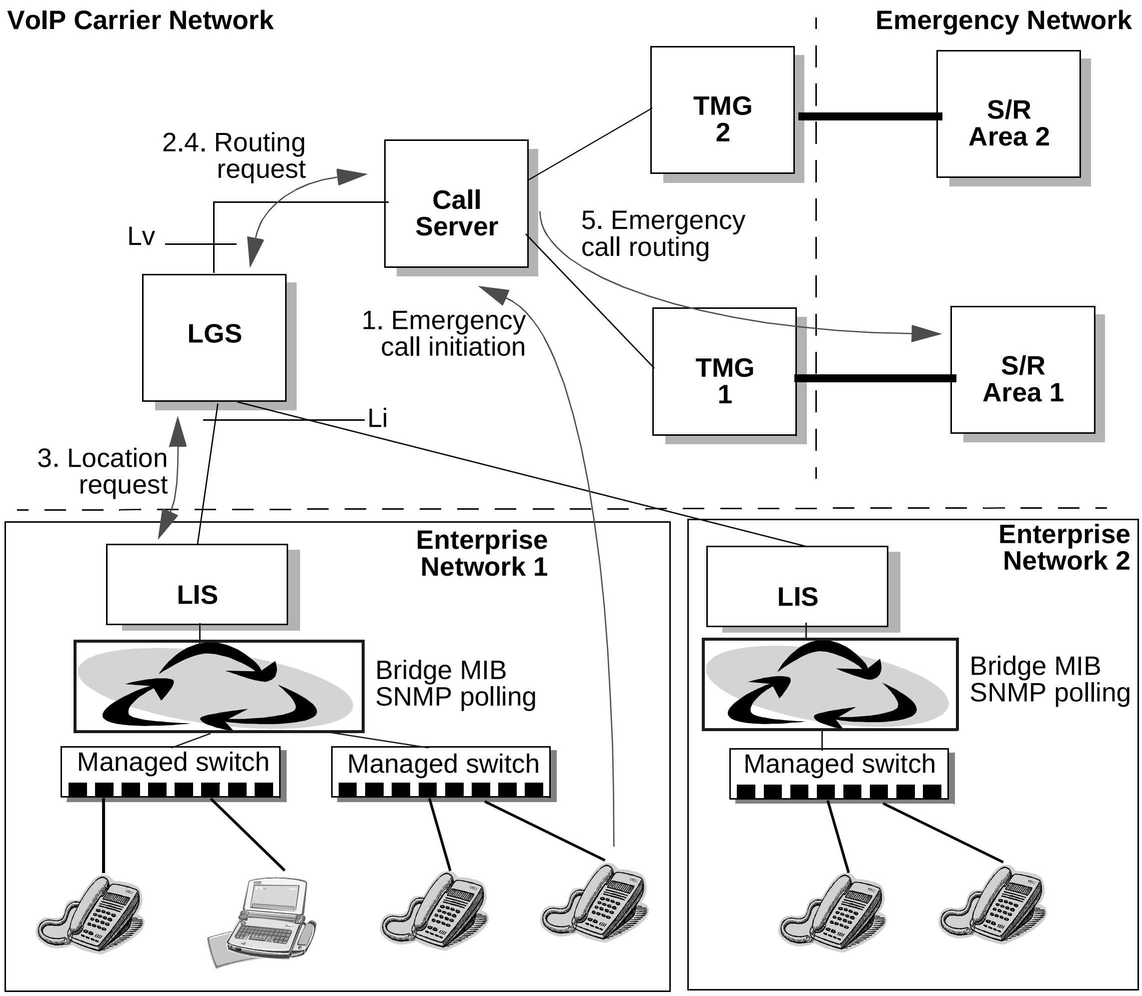


Figure A.1 An example carrier VoIP deployment serving enterprise customers with network based VoIP service from legacy clients connected via conventional managed switches. In this case the LIS implementation works via SNMP bridge MIB polling and associating connected client IDs with the specific managed switch and port - which can subsequently be mapped to a stored location for that port.

deployment, where the centrex call services are operated on an IP network with call serving functionality out sourced from the enterprise to the carrier.

In this example, it is suggested that each of the enterprises operates the voice network under the constraint that all voice clients need to be connected via specific IP switches supporting a standard SNMP bridge MIB that permits port scanning to occur and also permits the MAC address of connected clients to be retrieved.

Further, the client implementation and protocol are conventional but include the delivery of the client MAC address as part of the native call signaling with the call server.

These constraints permit the operation of the network such that the MAC address can be used as a query key between the call server and LGS (Lv) interface and the LGS and LIS (Li) interface. The LIS implementation in this case involves the continuous SNMP polling of managed switches according to provisioned data which includes the list of managed switches, their ports, and the nominal location of the end-cabling attached to those ports - as both a geodetic location and, optionally, a civic address. On each poll cycle, the LIS stores any connected MAC address values against the port records within this wire map.

A query to the LIS from the LGS, then, simply results in the stored location information in this wire map being keyed from the provided client MAC address in the query. This location information is returned for subsequent processing by the LGS as described in the body of this paper.

This example illustrates how the complexities of location determination in the access network are abstracted away from the rest of the emergency call handling. Other examples of LIS implementations would be those that could map a DSLAM port to a physical home address location for ADSL broadband internet based subscribers. Again, the details of how this particular LIS performed this function would be hidden from the rest of the VoIP network.

Certainly the solution described for the LIS in this scenario may be considered somewhat inelegant but, on the other hand, during the period of further development of native location capabilities, it is likely the sort of implementation that will be required to support legacy systems. The more important point is that there is now a seamless migration path to native positioning systems that will not impact the network beyond the access interface to the LIS.

The example in this appendix is intended to illustrate the manner of implementation of the LIS function in the context of a theoretical deployment. It is not intended to represent any specific real existing deployment.

Appendix B Extracts of NENA specification

The following tables are annotated extracts from [2], NENA-05-xxx - "NENA Standard for the Implementation of the Wireless Emergency Service Protocol E2 Interface". They are provided to highlight some of the parameters and structures that have been referenced in the main text of this paper. For full context of each of the pieces of information shown, the referenced document should be consulted.

ESRK - used to route the call and which subsequently identifies the call.

Element /Parameter	Reference	Type
Package Type = Query With Permission	9.1.1	M
Transaction ID	9.1.2	M
Component Sequence	9.2.1	M
Component Type = Invoke(Last)	9.2.2	M
Component ID	9.2.3	M
Operation Code = Private TCAP	9.2.4	M
Parameter Set	9.2.7	M
ESMEIdentification	9.3.1	M
PostionRequestType	9.3.2	M
EmergencyServicesRoutingKey (esprKey)	9.3.3	O
CallbackNumber (esprKey)	9.3.4	O
EmergencyServiceRoutingDigits (esprKey)	9.3.6	O

Figure B.1 The Emergency Services Position Request (ESPOSREQ) message parameters.

PosInfo - The Geodetic encoding of the caller's location. Also includes a Position Source parameter which is a code point indicating the positioning technology used.

Company ID - A unique identifier for the voice network

Location Description - including an XML encoding of the civic address

Element /Parameter	Reference	Type
Package Type = Response	9.1.1	M
Transaction ID	9.1.2	M
Component Sequence	9.2.1	M
Component Type = Return Result(Last)	9.2.2	M
Component ID	9.2.3	M
Parameter Set	9.2.7	M
PositionResult	9.3.8	M
PostionInformation	9.3.9	O
CallbackNumber	9.3.5	O
EmergencyServiceRoutingDigits	9.3.7	O
GeneralizedTime	9.3.11	O
MobileIdentificationNumber	9.3.12	O
InternationalMobileSubscriberIdentity	9.3.13	O
MobileCallStatus	9.3.14	O
CompanyID	9.3.15	O
Location Description	9.3.16	O

Figure B.2 The Emergency Services Position Request response (esposreq) message parameters.

2. Ellipsoid point with uncertainty

	H	G	F	E	D	C	B	A
4		0	0	0	0	0	0	1
5	Lat sign	MSB						
6				Degrees of Latitude				
7								LSB
8	MSB				Degrees of Longitude			
								LSB
11	Spare				Uncertainty code			
12	Spare				Confidence			

These values are further defined in ANSI T1.628-2000

Figure B.3 One of the geodetic location encodings supported in the Position Info parameter.

The following tables show the XML tags which are defined for the location description parameter in the esposreq and which include tags for description of civic address information.

Name	Tag	Max Chars	Type	Description
Cell ID	<CEL></CEL>	6	ANV	Identification number indicating a geographic region of wireless coverage. i.e. the cell site where the call is received. Valid Values: 0-2047
Company ID 1	<CPF></CPF>	5	ANV	NENA registered Company Identification code for Service Provider providing wireline or wireless service to the customer.
County ID	<COI></COI>	5	ANV	County Identification Code
Customer Name	<NAM></NAM>	32	ANV	Subscriber Name
Emergency Medical Service Responder	<EMS></EMS>	25	ANV	Name of Emergency Medical Service Responder associated with the ESN of the caller.
Emergency Services Number	<ESN></ESN>	5	ANV	Emergency Service Number associated with the House Number and Street Name and Community Name. *Note: The Service Provider, providing the E9-1-1 Selective Routing will assign ESN's.*
Fire Department Service Responder	<FIR></FIR>	25	ANV	Name of Fire Department Service Responder associated with the ESN of the caller.
House Number	<HNO></HNO>	10	ANV	House Number

Name	Tag	Max Chars	Type	Description
House Number Suffix	<HNS></HNS>	4	ANV	House Number Extension (e.g. ½)
Law Enforcement Service Responder	<LAW></LAW>	25	ANV	Name of Law Enforcement Service Responder associated with the ESN of the caller.
Location	<LOC></LOC>	60	ANV	Additional location information (free formatted) describing the exact location of the Calling Party Number. (e.g., "Apt 718" or "cell sector A") Emergency Response Location (ERL) - A Location to which a 9-1-1 emergency response team may be dispatched. The location should be specific enough to provide a reasonable opportunity for the emergency response team to quickly locate a caller anywhere within it. *This information may be displayed at the PSAP*
MSAG Community	<MCN></MCN>	32	AV	Valid service community name as identified by the MSAG
Post Directional	<POD></POD>	2	AV	Directional Trailing street direction suffix. Valid Entries: N S E W NE NW SE SW
Prefix Directional	<PRD></PRD>	2	AV	Directional Leading street direction prefix. Valid Entries: N S E W NE NW SE SW
Sector ID	<SEC></SEC>	2	AN	Sub set/section of a cell. Valid Values: 1-15

Name	Tag	Max Chars	Type	Description
State	<STA></STA>	2	A	Alpha U.S. state or Canadian province abbreviation, i.e. TX (Texas), ON (Ontario)
Street Name	<STN></STN>	60	ANV	Valid service address of the Calling Party Number
Street Name Suffix	<STS></STS>	4	AV	Valid street abbreviation, as defined by the U S Postal Service Publication 28. (e.g. AVE)

Appendix C Callback number considerations

One of the current limitations of the emergency services network is the ability to support callback number reporting to the PSAP where that callback number exceeds the the number of digits used for a normal local dialable number. Examples of callback numbers that may not be supported are:

- International callback numbers such as international roaming cellular callers or, in future, international roaming VoIP callers.
- Enterprise callers to emergency services where the terminal callback number is not delivered in the call setup information.

The use of E2 as a dynamic query interface also facilitates the delivery of callback information. Since this information is delivered out of band from the call setup, it isn't subject to the same constraints as imposed by the selective router and CAMA trunk infrastructure.

As noted in the following diagram, the callback number is one of the parameters in the esposreq message in ESP. This allows the originating voice network which uses the E2 interface the ability to deliver an appropriate callback number, if available, for the particular call in progress. The LGS then can also be used to query the access network or be informed by the Call Server, as appropriate, of a callback number to cache in anticipation of the PSAP query.

Element /Parameter	Reference	Type
Package Type = Response	9.1.1	M
Transaction ID	9.1.2	M
Component Sequence	9.2.1	M
Component Type = Return Result(Last)	9.2.2	M
Component ID	9.2.3	M
Parameter Set	9.2.7	M
PositionResult	9.3.8	M
PostionInformation	9.3.9	O
CallbackNumber	9.3.5	O
EmergencyServiceRoutingDigits	9.3.7	O
GeneralizedTime	9.3.11	O
MobileIdentificationNumber	9.3.12	O
InternationalMobileSubscriberIdentity	9.3.13	O
MobileCallStatus	9.3.14	O
CompanyID	9.3.15	O
Location Description	9.3.16	O

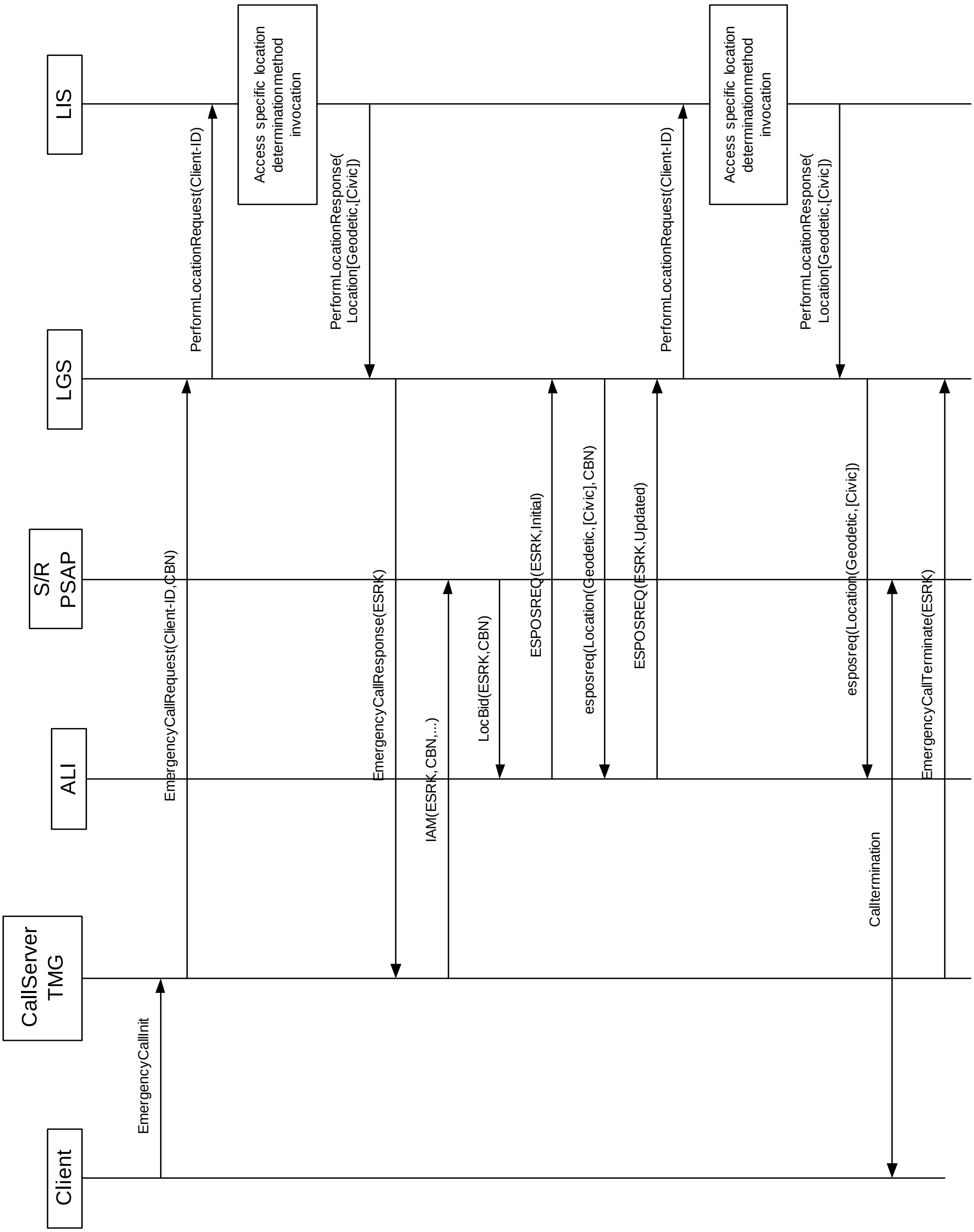
Callback Number - Option to use for the full, dynamically determined, callback.

Figure C.1 The Emergency Services Position Request response (esposreq) message parameters, highlighting the callback number.

It should be noted that this does require the E2 interface implementation to support full international encodings of callback number to be delivered to the ALI and for the ALI to subsequently be able to effectively deliver this information to the PSAP. However, these enhancements, if necessary, are considerably less onerous to deliver than upgrading the trunking elements to all PSAPs.

Appendix D Signaling Flow

The following shows a consolidated end to end signaling flow for the various signaling scenarios discussed in this paper. It includes the scenario of a mid-call location update request from the PSAP.



Mobile Location Center

An Architecture for E9-1-1 in VoIP Networks

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